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TRANSPARENT METAL AND NEW POTENTIALITIES FOR OPTICAL STRESS TESTING

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One of the most powerful methods for studying the stresses arising in various parts of constructions is the optical method. Such studies are of necessity conducted on models made from transparent material. Inasmuch as amorphous materials (glass, plastics, etc.) are used for modeling, the problems that may be studied by this method are limited to those in which it is possible to disregard the structure of the metal and consider it an isotropic homogeneous body. Thus, such important phenomena as cold hardening, creep, fatigue, residual stresses, recrystallization, and all problems concerned with heat treating and cold working of metals cannot be studied by this method.

The most important problem therefore, from the standpoint of further development of the method toward direct solution of production problems, is that of finding transparent materials which have a polycrystallic structure and mechanical properties approximating those of metals. This problem was solved by A. V. Stepanov (ZhTF, 19, 205, 1949) in the Leningrad Physicotechnical Institute, Academy of Sciences USSR. As early as 1933, he established that halide salts of silver and thallium and various alloys based on them fully satisfy these requirements. From the standpoint of microstructure and mechanical properties, these substances, of which silver chloride is a typical representative, act exactly like metals and, being transparent, may be called "transparent metals."

According to Stepanov's research, silver chloride, crystallizing in a cubical form, forms homogeneous transparent polycrystallic specimens which easily undergo all the forms of hot and cold working applied to metals, including pouring, stamping, annealing, cutting, etc. As with metals, it is possible, by varying the treating methods, to modify the crystal structure of the specimen made from AgCl and thus change its mechanical properties.

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Detailed study of the mechanical properties of silver chloride showed that at room temperature it has properties similar to copper but with about one tenth the normal strength of copper. Externally, it resembles lead; it is easily bent and can be scratched with a knife. Silver chloride, like metals, has the ability to harden as a result of plastic deformation (cold hardening), and this hardening may be removed by annealing either as a result of simply removing the stress (relaxation) or as a result of recrystallization. At room temperature, processes leading to removal of cold hardening are practically absent; retention of cold hardening over a period of 2 years has been observed.

Young's modulus for a pressed specimen in a cold-hardened state is about 4,500 kilograms per square millimeter.

Silver chloride crystals are optically isotropic when unloaded. Double refraction occurs under the action of external loads, disappearing as the load is removed. Internal residual stresses in the specimen are accompanied by residual double refraction, which disappears (along with the stresses) as a result of proper heat treating.

Silver chloride pieces are usually yellow or violet and have an oily gloss. The color can be eliminated through the use of light filters which cut off the active part of the spectrum.

Since **silver** chloride and other "transparent metals" have structures, mechanical properties, and mechanisms of stress redistributions under the action of external factors which are qualitatively similar to those possessed by metals, they are invaluable for modeling purposes and disclose new potentialities for optical methods of studying stresses. With their aid, it may be possible to study those processes which could not be studied previously, such as the interaction between grains and the boundaries between them, relaxation, recrystallization, kinetics of metalworking processes including forging, rolling, annealing and cutting, residual stresses, etc.

As examples of the applicability of "transparent metals" for studies of this kind, Stepanov listed some of the results of his studies of residual stresses and their changes with time, stresses during tension and circular bending of a polycrystallic specimen, and the behavior of individual grains in large-crystal specimens in compression and extension. In the latter case, he noted that, despite the homogeneity of the fixed external load, the stresses within the specimen varied from point to point in both magnitude and direction. Moreover, the stresses also changed within a single grain.

Stepanov also introduced a photograph (using a light filter) of a large-crystal specimen under load obtained with crossed Nicol prisms (stress of 820 **grams** per square millimeter, area 8 by 2 square millimeters; the axes of the Nicol prisms were placed at an angle of 45 degrees with the direction of elongation). This photograph, which clearly shows the boundaries between crystals, represents the stress states of individual sections of the specimen, determined not only by the external forces, but also by the interaction of the grains (anisotropy of the crystal's elastic constants). This picture comes out very well in the color photography used in the work.

Stepanov points out that removal of the load causes the picture to disappear for small loads. But if the load exceeds a certain (low) value, then residual stresses are observed, being localized chiefly along the boundaries of the grains and the shear lines.

He also points out the necessity for studying further the properties of "transparent metals" and for developing the laws of modeling and similarity (dimensional analysis). There is no doubt that "transparent metals" will be used in the very near future for studying processes occurring in real metals. It is hoped that they will solve a number of very important practical problems.

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